Applied Evolutionary Ecology Part 1: Ecological Traps

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Biol 417: Evolutionary Ecology

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Overview

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Everything we have covered so far (biogeography, ecology of sex, evolution of sociality, etc.) is 'pure science' driven by the desire to understand the natural world.

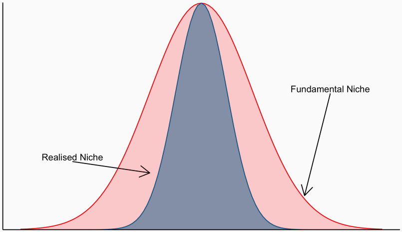
... but evolutionary ecology has many clear practical applications (e.g., species management, conservation, genetic hybridisation with engineered species, etc.).

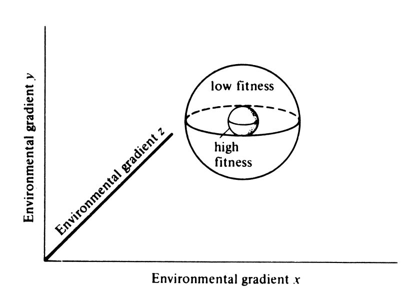
If applied wisely, the knowledge gained from the field of evolutionary ecology can be vital for improving our relationship with the natural world.

For the rest of the course we will be focusing on applied evolutionary ecology for a number of key environmental challenges.

Ecological Traps

Ecological niches





Source: Pianka (2000)

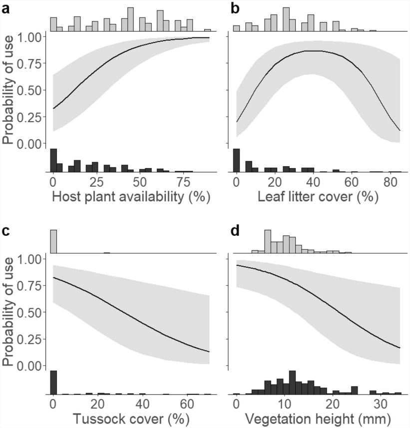
Species have constrained ecological niches the have been shaped by their evolutionary history.

Some are specialists, others are generalists, but all species have a set of conditions under which they do well ($R_0 \geq 0$), and a set of conditions under which they will struggle ($R_0 < 0$).

Organisms will have a preferences for habitats where $R_0 \geq 0$, and will avoid those where $R_0 < 0$.

Mountain Ringlet (*Erebia epiphron*) oviposition site sel.

Source: Wikipedia



Ewing *et al.* (2020)

Habitat Selection cont.

Organisms use cues in their physical environment to guide their choice of habitat.

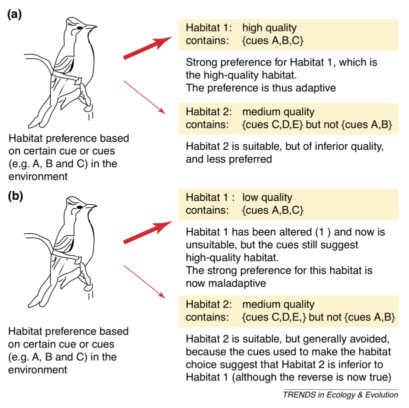
These preferences are adaptive because they rely on cues that have been reliably correlated with survival and reproductive success over evolutionary time.

E.g., Relying on patterns of vegetation structure, an individual can choose a territory that will have a good availability of food or cover (may be contemporaneous or future).

Challenge: If an environment changes suddenly, the normal cues might no longer correlate with the expected outcome and the evolved responses might no longer be adaptive.

Ecological traps

An **‘Ecological Trap’** describe the situation in which an organism’s choice of habitat results in $R_0 < 0$ because of a recent anthropogenic change in the environment that broke the normal cue-habitat quality correlation.



Schlaepfer *et al.* (2002)

In other words, a trap arises when the organism is constrained by its evolutionary past to make a mistake despite the presence of suitable conditions elsewhere.

Nest selection by grassland birds

Grassland birds prefer to nest in habitats with low vegetation structure.

Source: Audubon New York

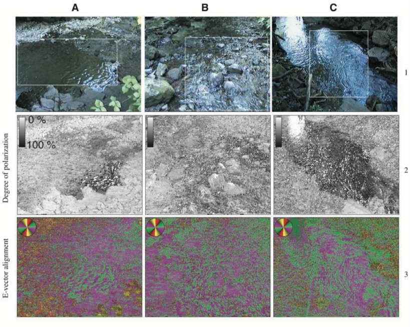
Pastures have similar structural cues as natural grasslands

Source: USGS

...but spring hay harvesting results in higher nestling mortality (Best, 1986).

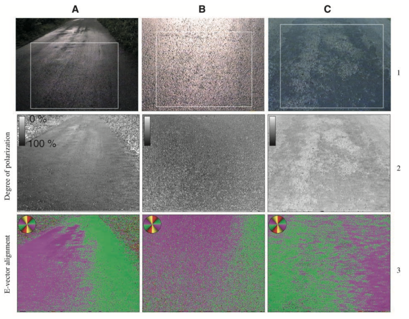
Source: Heritage Tractor

Mayflies (*Ephemeroptera*) use horizontally polarized reflected light to identify ponds where they can lay eggs.



Kriska *et al.* (1998)

... but asphalt also polarizes light horizontally and mayflies sometimes lay their eggs mistakenly on a dry road.



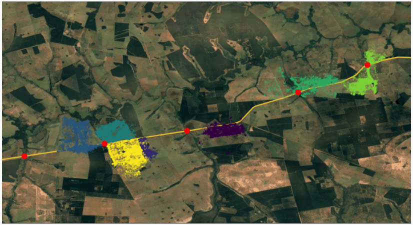
Kriska *et al.* (1998)

Giant anteaters and roads

Giant anteaters (*Myrmecophaga tridactyla*) forage on ants and termites and have few natural predators.

Source: Wikipedia

They readily occupy roadsides which provide good foraging (Noonan *et al.*, 2021)



Noonan *et al.* (2021)

...but don't 'fear' vehicles and are eventually roadkilled (Ascensão *et al.*, 2019).

West Indian Manatee (*Trichechus manatus*) select winter habitat with water >20 °C.

Source: National Geographic

Power plant effluent creates attractive sites north of traditional wintering areas (Shane, 1984)

Source: Wikimedia Commons

... but interruption of plant operation (e.g. for maintenance) strands manatees in inhospitable waters resulting in cold stress and possible mortality (Packard *et al.*, 1989).

Sea turtle hatchlings

Sea turtle hatchlings rely normally on light cues from the open horizon to orient and migrate toward the ocean after emerging from the nest

Source: Hakai Magazine

... but light pollution from beachfront structures can cue hatchlings to migrate inland instead, where survival is unlikely Witherington (1997).

Source: Hakai Magazine

Applications for conservation and wildlife management

Traps versus disturbances

In ecological traps, the agent of decline is the mismatch between the Darwinian algorithms of an organism and the actual state of the (changed) environment.

Population declines can also result from blatant disturbances, where the agent of decline affects the organism directly.

Conservation strategies for traps and disturbances are very different.

Traps versus disturbances cont.

The Cape vulture (*Gyps coprotheres*) prefer to forage from high perch sites and are often electrocuted when perching on high-voltage electricity towers (Mundy, 1983)

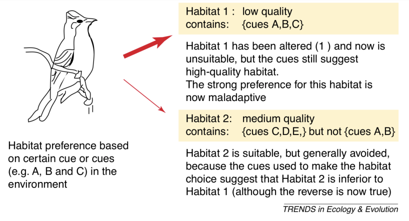
Source: Endangered Wildlife Trust

... but they are also regularly poisoned and shot.

Source: National Geographic

Traps and wildlife management

Key is identifying the mechanism causing individuals to behave maladaptively (i.e., disconnect between current cue and environmental suitability).



Schlaepfer *et al.* (2002)

Consideration of the social and physical environments in which a species evolved, and how present conditions differ from those in their environments of evolutionary adaptedness, could provide insights into how to mitigate the trap.

Traps and wildlife management cont.

If a population decline is due to a trap, manipulative experiments (e.g. choice experiments) are essential to identify the cues for a given behavior.

In cases where only a novel cue is causing a trap, a relatively minor adjustment might put organisms back into an environment in which their 'Darwinian algorithms' are adaptive again.

For example, managers now successfully prevent hatchling sea turtles from migrating inland by shading beachfront lights or using lights with wavelengths to which the hatchlings are less responsive Witherington (1997).

We also need to ensure our efforts are not creating ecological traps.

Wood ducks (*Aix sponsa*) pops. were in serious decline due to habitat loss and hunting.

Nest boxes were erected in clusters over open marshes.

Source: National Audubon Society

Wood ducks normally nest in tree cavities and females often follow established nesters to active nests and lay eggs in the same nest.

By placing boxes in groups over open water, managers made it too easy for females to follow others to their nests, resulting in clutches of 30–50 eggs that could not be incubated properly, resulting in population declines (Semel & Sherman, 2001).

Ecological Traps Take Homes

Organisms will have a preferences for habitats where $R_0 \geq 0$, and will avoid those where $R_0 < 0$.

When a recent anthropogenic change in the environment breaks the normal cue-habitat quality correlation organisms can find themselves at risk of ecological traps.

An evolutionary trap occurs in any situation where a sudden anthropogenic change in the environment causes an organism to make a decision that normally would be adaptive, but now results in a maladaptive outcome.

If we can understand the mechanisms underlying the disconnect, an ecological trap can be straightforward to correct.

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